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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

BEFORE THE

Federal Communications Commission

ORIGINAL FILE

In the Matter of Amendment of Section 2.106 of the Commission's Rules to Allocate the 1610 - 1626.5 MHz and the 2483.5 - 2500 MHz Bands for Use by the Mobile-Satellite Service, Including Non-Geostationary Satellites.	)	ET Docket No. 92-28 RM-7771 PP-29 ~~PP-32~~ 32 RM-7773 PP-30 PP-33 RM-7805 PP-31 RM-7806

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COMMENTS OF CELSAT, INC.

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COMMENTS OF CELSAT, INC.

Celsat, Inc., a petitioner in the above-captioned proceeding, hereby files its Comments in response to the Commission's Notice of Proposed Rule Making and Tentative Decision ("NPRMTD"), 7 FCC Rcd 6414 (September 4, 1992), in the same proceeding.[1]

[1] Although CELSAT filed a separate petition for rule making and request for Pioneers Preference, docketed as RM-7927 and PP-28, respectively, these docket numbers are not included in the caption of the subject proceeding. Yet, the Commission stated its intent that [t]his action also responds to petitions for rule making filed by Constellation Communications, Inc., [*et al.*] and CELSAT, Inc. (CELSAT)." [Emphasis added.] 7 FCC Rcd 6414, at ¶2.

In the NPRMTD the Commission made certain decisions which effectively partially, *albeit* erroneously, dismissed CELSAT's petition for access to the former RDSS L/S-Band for hybrid purposes, while it took no action on CELSAT's pending request for Pioneers Preference. On October 5, 1992 CELSAT petitioned for partial reconsideration of the Commission's NPRMTD insofar as it purported to dismiss, with finality, CELSAT's proposal for use of the subject band. Not a single party opposed CELSAT's petition for reconsideration. Accordingly, CELSAT will not re-raise the points which it clarified in its reconsideration petition.

SUMMARY

Celsat has identified the following issues and subject areas for additional comment:

-- *Relative merits of LEO vs GEO systems*:

CELSAT demonstrates that the Commission has failed to notice the relative merits between LEO/GEO systems when considered in the context of newer, contemporary systems like CELSAT's proposed HPCN.

-- *Commission predisposition toward LEOs*:

CELSAT is concerned that the Commission has a predisposition is favor of LEO systems, and that such a bias might lead to the unwarranted exclusion of any GEO system in the subject band.

-- *LEO/GEO Sharing*:

CELSAT expands on its already comprehensive showings that LEO and GEO systems can share, and explains that the real factors influencing sharing compatibility do not relate to the orbital characteristic of the particular system.

-- *Compliance with power flux density limits*:

CELSAT explains that there are potentially serious problems with the strict PFD limits which the Commission has proposed for the downlink, and equally serious concerns not yet being recognized in the uplink, and it proposes solutions in each case.

-- *Bi-directional operation in the 1610-1626.5 band*:

CELSAT submits that if bidirectional use of the L-Band is to be permitted and if IRIDIUM is given access to that band, then the Commission ought to permit bi-direction use of the S-band by others, particularly CELSAT.

-- *Coordination with GLONASS, and Health Effects*:

CELSAT offers an analysis of the GLONASS coordination issue.

RELATIVE MERITS OF LEO VS GEO SYSTEMS

At several points throughout the NPRMTD the Commission makes reference to the many promised service and operating benefits which the proponents have so glowing attributed to low earth orbit

("LEO") satellite technology, and their respective LEO and MEO proposals in particular.[2] While CELSAT would not dispute that there is some merit to and demand for LEO systems, it would caution that some of the advantages of these systems have been overstated and the difficulties of technical complexity, cost and internationally politically sensitivity glossed over. The latter consideration, which bears on the problems of and pressures on the so-called "Big LEO" systems to:

(i) raise funding among international participants;

(ii) achieve frequency coordination with potential international competitors, particularly including INMARSAT;

(iii) establish strategic partnerships with international vendors (to "spread the wealth"); and

(iv) obtain operating approvals and revenue sharing arrangements with foreign PTTs,

ultimately will affect the time table within which they realistically can expect to be operational at economically viable geographic service levels.

In contrast, advanced, state-of-the-art geostationary systems such as that proposed by Celsat not only promise all of the same service and geographic coverage benefits for US customers, but even more functionality and user capacity at much lower costs and

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[2] See, e.g., NPRMTD at ¶ 1 (". . . new and low cost services, with a *potentially* worldwide scope, such as voice, facsimile, and data messaging, and fleet surveillance and control"); ¶5 (". . . need for additional voice and data services which can best be provided through LEO satellites"); and ¶13 (". . . non-geostationary systems offer promise of significant new benefits to both domestic and international communications users" . . . "LEO satellite systems appear to offer significant economies of operation over geostationary systems for both system operators and consumers").

greater spectral efficiency than any proposed LEO system. But perhaps most significant in this worldwide economy and in view of the apparent domestic infrastructure priorities of the new administration, CELSAT promises unique advantages in that:

-- build-out can be started in the shortest possible time frame, subject only to Commission approval (within two years on the ground, three years for the space segment);

-- CELSAT's HPCN design employs 100% U.S. technology, all of which is proven and available;

-- CELSAT requires no foreign approvals, minimal cross-border frequency coordination, and no strategic off-shore vendor partnerships with which to split up component manufacturing, etc.;

-- only CELSAT offers the tremendous capacity and end user bandwidth necessary to truly create a significant wireless infrastructure of its own, while complementing new and existing infrastructures of others; and

-- only CELSAT offers the potential volume and network scope to create significant new domestic markets for infrastructure systems and components, and the economies of scale to ensure both low cost and multiple sources of supply for the greatest variety of new generic and proprietary wireless terminals.

The details of CELSAT's superior strengths in each of these respects are amply set out in CELSAT's Petition for Rule Making, its Pioneers Preference Request, and its Consolidated Reply -- all previously filed in this proceeding -- and need not be repeated in these comments.[3] However, for convenience, attached to these Comments as Appendix A is a short list high lighting CELSAT's superior advantages and capabilities, particularly as they relate

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[3] See also, CELSAT Petition for Reconsideration, ET Docket 92-28, October 5, 1992; also, CELSAT Comments, Gen Docket NO. 90-314, November 8, 1992.

to contributing to the resolution of some of the important policy questions confronting this Commission.

COMMISSION PREDISPOSITION TOWARD LEOS

Although procedurally satisfied that nothing on the face of the proposed new MSS rules will preclude consideration of geostationary satellite proposals and geosatellite operations in the subject L- and S-Band pair, Celsat is sensitive to a perceived *de facto* bias on the part of the Commission toward low earth orbit-only use of these bands. This is reflected, for example, at certain points throughout the NPRMTD, and needs to be corrected -- both for the record, and for the public's benefit if, indeed, the Commission hopes to optimize the use of this scarce piece of remaining spectrum.[4]

Accordingly, CELSAT urges the Commission to take a much closer "fresh look" at what the two technologies (LEO vs GEO) are really capable of, what will be required and what will be gained -- technically, economically, and politically -- before reaching a final judgment on the relative merits of LEOs vs. GEOs. And in making this fresh look, CELSAT would refer the Commission to the GEO concepts and advantages summarized from its past pleadings in

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[4] See, for example, NPRMTD, at ¶13 ("[w]e therefore believe it important to make spectrum available for operation of MSS LEO services"); ¶17 ("[i]n considering the type of services to be authorized, we are aware that it may not be feasible for geostationary and non-geostationary systems to share the same frequencies"); ¶19 ("[a]ccordingly, we solicit comment on the potential of each of the proposed access methods to support service by multiple LEO licensees in the new MSS bands since we tentatively conclude that the public interest is best served by multiple MSS LEO operators"); and ¶ ("[t]his action is being initiated to allocate spectrum for a low earth orbit satellite service").

Appendix A hereto as being more characteristic of today's GEO technology than, for example, those of the AMSC system which has also been vying for access to these bands. Considering that CELSAT's HPCN GEO approach offers all the advantages and none of the disadvantages (particularly their lesser capacity, higher unit costs, and international uncertainty) of LEO systems, CELSAT submits that the Commission might reasonably conclude that Big LEO technology had a short window of opportunity which might have already passed it by. The Commission ought to be asking itself why would it be so strongly endorsing Big LEO's, with all the technical complexity and political baggage that attaches to them, when so much more immediate market potential is available with the simplicity of the latest generation GEOs.

LEO AND GEO SHARING

The Commission expressed concern that "it may not be feasible for geostationary and non-geostationary systems to share the same frequencies" and that "sharing of the RDSS bands by LEO and geostationary systems may require severe limits on power and frequency that could render both systems unworkable". NPRMTD, at ¶17. CELSAT fully addressed this issue and confirmed its unique ability to share the RDSS L/S-Band either with IRIDIUM or with the Gang-of-Four in its Consolidated Reply. (See, Consolidated Reply, April 24, 1992, at pp. 6-9.) More specifically, it demonstrated how, by converting to a time duplexing mode, it could operate almost as effectively in space in the 2483.5-2500 MHz S-Band if Iridium were authorized to operate exclusively in the 1616-1626.5

MHz L-Band.[5] Id., at pp. 7-8. Alternatively, CELSAT demonstrated how, operating as a frequency duplexed spread spectrum CDMA-based system, it could share the full band pair with the Gang-of-Four. Id., pp. 8-9. CELSAT's inherently accommodating capability to share with others apparently was missed by the Commission, so CELSAT offered still further details in its Petition for Reconsideration, the technical explanation for which appeared as Attachment B thereto and is included herewith as Appendix B. See, CELSAT Petition for Reconsideration, ET Docket 92-28, October 5, 1992.

By way of still further comment on the LEO/GEO compatibility issue, while there are clearly recognizable band-sharing compatibility issues between diverse mobile satellite system designs, CELSAT submits that these issues do not arise from the LEO/GEO orbital difference, but arise primarily from other, equally fundamental but technical design differences. These include:

- Time-duplexed vs. frequency duplexed designs (which lead to insurmountable near/far problems between nearby mobile users when, for example, one is attempting to receive while another is transmitting in the same band);

- Time-duplexed systems with mutually non-synchronous time duplexing cycles (same problem as above);

- Systems having significantly different subscriber antenna gains (low gain users will require a significantly larger ground signal power density which will then interfere inordinately with the high gain user -- i.e., a downlink problem); and

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[5] Subsequent to CELSAT's proposed ability to share the L/S-Band spectrum with IRIDIUM, Motorola grasped the concept, in part, and petitioned the Commission to make the S-band available to the Gang-of Four to the exclusion of CELSAT. Motorola's Petition for Rule Making, September 22, 1992.

- Systems having a significantly different G_{sat}/R^2 or system transmission loss factors where G_{sat} is the satellite antenna gain, and R the user-to-satellite range (low G_{sat}/R^2 or high system transmission loss requires high user EIRP spectral density which then interferes inordinately with the high EIRP satellite receiver -- i.e., an uplink problem).

None of these issues are inherently related to the LEO/GEO orbital natures. For example, as compared to any of the current LEO designs, the very large aperture antenna that is central to the CELSTAR design, and, in many respects possible only in geosynchronous orbits, more than makes up for the added range loss so that CELSTAR provides the *lowest* system transmission loss, smallest beam footprints, and therefore can operate at the *lowest* user EIRP spectral density.

Therefore, insofar as CELSAT is aware, the Commission's perception of inherent incompatibility between LEO and GEO systems is misplaced, and any attempt to reflect such misinformation in either the rules or Commission policy pertaining to the subject bands would be unwarranted, arbitrary and inappropriate.

COMPLIANCE WITH POWER FLUX DENSITY LIMITS

The Commission has rejected many proposals requesting relaxation of the power flux density limits to be applied to the use of this band for MSS purposes. Here, too, CELSAT has previously provided the Commission considerable technical comment. But subsequent developments arising out of the WARC-92 proceedings warrant some re-adjustment of CELSAT's previous views on this matter, and CELSAT now believes that there is need for still further refinement of the applicable flux density rules -- slightly different from CELSAT's original contribution, and different from the Commission's NPRMTD proposal.

Sharing In the Downlink:

CELSAT submits that the Commission's proposed downlink flux density limits as set by Regulation 2566 are both unnecessarily restrictive, and too restrictive in different circumstances within the anticipated likely context of potentially varying types of MSS technical approaches in the subject band. CELSAT has previously expressed the concern that band sharing, unless it is to have drastic adverse effects on the circuit capacity and economic viability of at least some of the sharing participants, must be supported by *total* power flux density limits, administered and allocated individually among the prospective band-sharers, perhaps by the FCC itself.[6]

In the Mallinckrodt paper filed in Cc Docket No. 92-166,[7] CELSAT pointed out and developed the exact relations for describing how the capacity of a band-sharing system varies with total interfering flux density. For small *total* interfering flux density a system's capacity is independent of interference, but

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[6] See, "Band-Sharing Coordination of Wide-Band Mobile Satellite Services", Dr. Jack Mallinckrodt, August 31, 1992, attached to CELSAT Comments and Application, CC Docket No. 92-166, September 3, 1992, and attached hereto as Appendix C. While these technical comments were filed and served on all the interested applicant/parties well in advance of the September Comment date, not one of the Big LEO applicants even acknowledged them, let alone attempted to refute or dispute the merits. Clearly, as has been the case all along, the Big LEOs have been conspicuous by their silence in their efforts to not draw Commission attention to the sobering reality and complexity of band sharing among compatible systems of such diverse capacities which CELSAT persists in bringing to light.

[7] Id.

proportional to individual *allocated* flux density. For large *total* interfering flux density, the system's capacity becomes inversely proportional to the *total* interfering flux density. In between there is a "point-of-diminishing-return" which provides a reasonable objective for total interference flux density control. This is at the flux density that yields a *total* interference available power spectral density at the receiver input roughly equal to the thermal noise. For near omni-directional subscriber receiving antennas in the 2.4 GHz band this is about -139 $dBW/m^2/4kHz$. The -144 or -142 $dBW/m^2/4kHz$ limits are a reasonably conservative expression of this objective *only in the case where the total interference is most likely from a single interferer.*

In most other radio services this has commonly been the case -- i.e., within any one allocated band and coverage area, only one or at most a very small number of transmitters are liable to be interfering. Individual link flux density limits are a feasible and effective first step for administering mutual interference control in such cases.

Now, however, in the band-shared mobile-satellite services and particularly with the advent of the LEOs, there exists the prospect of multiple diverse systems, each with total transmitter populations varying from one to several tens (r.g. at orbital convergence points), all potentially operating in a single, commonly allocated band, in a single or overlapping coverage area (i.e., satellite beam footprints). The imposed interference now becomes the totality of all these interferers. Individual transmitters or satellites operating at a level of -144 dBW/m^2/4kHz (or, -142 in the proposed MSS case, given the proposed -3 dBW/m^2/4kHz relaxation) could result in a cumulative total flux density well beyond the point of diminishing returns, resulting in an inefficient power war and loss of overall capacity and economic viability well below optimum for the least efficient systems.

In addition, there may be a significant issue of how such individual flux density limits are to be applied -- i.e., per system, or per satellite ("space station"), or per some other basis? For example, how would the PFD limits apply to a LEO system that provides a high multiplicity of satellites covering the same frequency band at an orbital convergence point on the earth? Do the proposed regulations permit -142 dBW/m^2/4kHz for *each* space station (satellite) as literally specified? Surely this would violate the intent of the regulation as well as the equities and relative efficiency of alternative systems.

The essential element to a clear answer to all these issues seems to lie in total flux density control. And since it directly affects capacity and economic viability for each sharing provider, it would appear that FCC must play the central role in administration and allocation of any such total flux density control policy.

Clearly, this is a complex issue, but one which hopefully will be addressed in the negotiated rule making process in Docket 92-166. In anticipation of that opportunity CELSAT suggests that the following options and issues are suggestive of possible approaches to the significant problems:

> 1. TOTAL FLUX DENSITY POLICY -- Total allocated flux density in this band shall be no greater than 2.0 times reference isotropic thermal noise equivalent (defined as that flux density which would provide an available PSD of kTo (= -204 dBW/Hz) from an isotropic receiving antenna, i.e., approximately -138.9 $dBW/m^2/4kHz$ in the 2.48 GHz band).
>
> 2. MINIMUM STANDARD OF EFFICIENT FLUX DENSITY UTILIZATION -- In the absence of interference from other systems, any system licensed for operation in these bands shall meet a minimum PFD utilization efficiency standard of not more than -165 $dBW/m^2/4kHz$ per voice circuit per beam (or cell). (This is a function of voice encoding rate, Forward Error Correction coding, required Eb/No, and receiver noise performance.)
>
> 3. ALLOCATION UNIT -- Allocation of total PFD among various providers shall be on a *per system* basis. That is, each provider shall be allocated a subtotal PFD $dBW/m^2/4kHz$ for *its system*, not to be exceeded at any point on the surface of the earth, irrespective of the number of circuits, CDMA groups, beams, transmitters, or satellites responsible for the generation and lay-down of the PFD.
>
> 4. TREATMENT OF TIME DUPLEXED SYSTEMS -- For a time-duplexed system the flux density limit applies to the *peak* power during any on-period.
>
> 5. INCENTIVE FOR MAXIMUM FREQUENCY REUSE -- Allocation of total PSD among band-sharers shall be *in proportion to the number of cells or cell clusters over the U.S. in which the entire allocated band can be reused.*

Obviously, there will be different views on how these various matters should be resolved. Further, there are significant issues as to how the allocated flux densities, once defined, should be monitored and enforced. These appear to be suitable subjects for negotiated rule making. Meanwhile, although these proposals represent a significant extension of the FCC's proposed regulatory scheme, CELSAT submits that regulation in these respects will be essential to orderly development of spread spectrum band-sharing services and avoidance of the very kind of power-war chaos that existed in the days of radio broadcast before regulation in 1927.

Sharing In the Uplink:

Although the Commission did not request any specific comment on uplink sharing, CELSAT believes that it is important to pass along its observations on this aspect of the Commission's proposal, particularly as it relates to reliance on Footnote 731X. Footnote 731X, invoked over the 1610-1626.5 MHz band states, in part:

> "In the part of the band where such [Note 732, aids to navigation] systems are not operating, a value [of EIRP spectral density] of -3 dBW/4kHz is applicable."

This standard appears to open a serious potential for interference in a spread spectrum band-sharing environment.

As an example, for band-sharing systems having an individual subscriber unit spread bandwidth of the order of 1.25 MHz which is typical of CELSTAR and some of the other proposed CDMA band-sharing systems, this permits a subscriber EIRP as great as 156 watts. For comparison with CELSTAR, for example, a *single* such 156 watt ground transmitter would impose an interference power spectral density at the satellite approximately three times that of total CELSTAR system noise. This would essentially wipe out the CELSTAR design margin, which could only be regained by reducing the CELSTAR capacity to about one-third of its design value. Other band-sharing systems would be affected similarly.

For reference purposes, the estimated subscriber set EIRP spectral density for other proposed MSS systems, based on their published design parameters, is given in the table below:

SUBSCRIBER UNIT EIRP SPECTRAL DENSITY

System	Subscriber EIRP* dBW	Spread BW (MHz)	Subscriber EIRP PSD dBW/4kHz	Comments
CELSTAR	-9	1.25	-33.9	
AMSC	21	0.02	14.0	Worst case; no spreading
MOTOROLA	6.9	0.126	-8.1	Pulsed TD
LORAL/ QUALCOMM	0.3	1.25	-24.7	FD Option
TRW	-1.0	4.8	-31.8	
CONSTELLATION	1.0	0.5	-20.0	
ELLIPSAT	0.3	16	-35.7	

*Peak in time, average over users.

Of those systems that are inherently capable of band-sharing (that is, those which afford some degree of spread spectrum processing gain and do use the same band for downlink and uplink) all propose use of a subscriber EIRP Spectral Density less than or equal to -20 dBW/4kHz. For all these systems, LEO or GEO, a single transmitter exercising the Commission's proposed -3 dBW/4kHz EIRP limit in the direction of a mobile satellite would have seriously detrimental effects, and any significant number of such transmitters would effectively deny intelligible signals to the MSS services. CELSAT, therefore, strongly urges the Commission to adopt an additional rule, applicable over the United States, for the uplink subscriber power which would limit subscriber set power in the order of -20 dBW/4kHz, and set equivalent directivity limits at elevations above 20 degrees.

BI-DIRECTIONAL OPERATION IN THE 1610-1626.5 BAND

The Commission has sought comments on the feasibility of bi-directional use of the spectrum in the 1610-1626.5 MHz band. Its interest in this issue has do to with Motorola's proposed exclusive use of at least 10.5 MHz in this band for the timed duplex operation of its IRIDIUM system.

CELSAT suggests in the interest of efficient band pairing, that if the Commission adopts a final rule permitting bi-directional operation in the L-band, then it ought to permit the same use over the United States in the matching spectrum of the S-Band. As yet another alternative to its preferred use of the band pair even on a shared basis, CELSAT could use the 2483.5-2500 MHz in the S-Band on a time duplexed basis using spread spectrum CDMA modulation. If this use of the S-Band were permitted the Commission could, for example, accommodate IRIDIUM in the L-Band and CELSAT in the S-Band, thereby achieving multiple entry into the L/S-Band for MSS/RDSS purposes by the two most spectrally efficient and service-complementary systems, without leaving a large chunk of valuable satellite spectrum orphan.

COORDINATION WITH GLONASS AND RF HAZARDS

The Commission has requested comments on the feasibility of operating in the subject bands on a coordinated basis with GLONASS, and on whether there are possible health hazard effects of operating MSS handsets at the proposed frequencies . NPRMTD, ¶¶ 30 and 31. As to the GLONASS issue, CELSAT would refer the Commission to CELSAT's lengthy and comprehensive analysis of this potential problem appearing at Appendix D to its initial petition in RM-7927, a copy of which is included herewith, also as Appendix D.

Finally, as to health hazard effects, CELSAT is not able to respond to this concern at this time other than to point out that its handsets will operate at very low power, less than a tenth of a watt average power through the satellite. Special purpose devices requiring more than this level of power (e.g., notebook computers, video devices, etc.) will be operated with quite different spatial relationships relative to the end user's head and face, and presumably will therefore not present a health threat.

CONCLUSION

CELSAT respectfully requests that its comments herein be given full consideration, and its proposed additions and modifications to the Commission's proposed new MSS rules for the subject spectrum be adopted.

Respectfully submitted,
CELSAT, Inc.

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AN MSS SATELLITE-BASED SOLUTION TO MULTIPLE WIRELESS NICHE SYSTEMS

Brief Description and Background

CELSAT, Inc. is a relatively new venture based in California whose principal assets include U.S. Patent No. 5,073,900 granted in 1991. This patent covers the novel combination of hybrid space and ground mobile system using CDMA multiplexing and a network controller by which end user mobile handsets can be assigned transparently and dynamically back and forth between space- and ground-based radio communications channels within a wide range of user-requested bandwidths or data speeds, without conscious user intervention. CELSAT's proposed CELSTAR system will offer 100% ubiquitous coverage over the entire United States, including CONUS, Hawaii, Alaska, Puerto Rico and the Virgin Islands, with universal personal number accessibility, and will require only very low average power low cost omni-directional handheld personal communicators (less than a tenth of a watt through the satellite).

CELSAT's uniqueness lies in the fact that it has proposed a very broad array of the most desired and, in some instances, heretofore yet unattainable mobile services to be offered over *one wireless satellite-based system*. This will be achieved using state-of-the-art geostationary satellite-based technology as the integrating system platform, and ground-based cellular and microcellular subsystems operating within the same spectrum band(s) as vehicles for off-loading the heaviest mobile traffic in the most densely populated areas. By assigning traffic first to ground cells where accessible, and then only secondarily to the satellite (in effect, a ground cell tower in the sky), CELSTAR will eliminate for the majority of its users the potentially annoying effects of signal delay associated with geosatellite voice communications.

Whether communicating in either the space- or the ground-system mode, the objective of the CELSAT hybrid concept is to serve as a wireless local or regional loop -- a tetherless connection between the voice, data or video mobile/personal user and the closest practical point of interconnection to the traditional public switched or private wireline domestic or global networks. But most emphatically, CELSAT's HPCN is <u>not</u> a global by-pass system; it is not attempting to achieve or promote the avoidance of landline networks, but instead seeks to complement them. Together, its alternative space and ground cell service structure, coupled with its concept ability to get the user <u>off the spectrum</u> and onto the established wireline networks within the smallest possible geographic area, serve to ensure not just maximum conservation and re-use of the spectrum, but near infinite end user capacity.

CELSAT Is Proposing New, Low Cost, Ubiquitous Wireless <u>Mobile Services Offered Over One, Integrated System</u>

CELSAT's proposed CELSTAR HPCN will offer very low cost, high capacity ubiquitous mobile personal communications for voice, paging and messaging, high and low speed bidirectional data (up to 144 kbps), fax, one- and two-way compressed video, position determination and point-to-multipoint broadcast services to between 20 and 30 million U.S. customers and, conceivably, roaming capability for compatible PCS users of competing systems. While many of these kinds of services are either currently available or proposed by other systems, no proposal presently before the Commission has the technical capability, geographic coverage and capacity to offer all of them under one, integrated system.

CELSAT's Novel Hybrid Geostationary System Proposal Will Best Facilitate Many Pro- <u>Competitive and Pro-Service Policy Objectives</u>

The Federal Communications Commission is confronted, on the one hand, by:

(i) the publics' demand for both a greater variety and greater access to lower priced wireless mobile communications services,

(ii) the desire by increasing numbers of potential suppliers and entrepreneurs to supply such services, and

(iii) the nations economic ambition to become the first and the leader in the deployment of such capabilities.

On the other hand, it faces a chronic shortage of spectrum and the reluctance of embedded spectrum users to relinquish frequencies in favor of newer needs and technologies. More so than any other existing or proposed use of the commercially available spectrum, CELSAT's hybrid system approach includes many inherent functional and structural features especially well suited to relieving if not solving at least some of these policy dilemmas. To the extent proprietary systems, such as CELSAT's CELSTAR, contribute to solving these conflicting problems, the sooner end users will realize access to the new wireless services which everyone appears to agree are so heavily in demand.

Among the most significant and relevant features of the CELSAT hybrid approach are the following:

- **Extraordinary Capacity and Spectral Efficiency** -- Of great significance to regulators, policy makers and other potential users of the Region 2 spectrum, is that CELSAT's hybrid approach to re-assigning spectrum subbands alternatively between space and ground permits both tremendous capacity and the greatest variety of services and functionality at the highest currently attainable spectral efficiency. This, of course, conserves scarce spectrum for yet other uses and providers. CELSAT has described an HPCN system capable of between 55,000 and 61,000 VG space channels, and easily 10 to 15 times that many ground-based channels, using no more than 32-37 MHz of total spectrum. This amounts to about 1903 VG circuits per MHz of space band capacity, compared to IRIDIUM's 419 attainable equivalent circuits, and the hundred or so circuits attainable by any other MSS proposal to date. This comparison does not take into account CELSAT's proposed ground re-use of the very same spectrum -- something no other system has ever proposed or shown a technical capability to offer.

- **Incremental Expandability** -- In contrast to terrestrial-based systems, CELSAT's space component will ensure nationwide ubiquitous coverage from the outset, with between 100 and 149 separate space cells or spot beams, each re-using 100% of the available spectrum. At any time it will be possible to grow system capacity and enhance service quality by selectively reassigning subbands in any one or more spot beams to cellular-like and/or PCS-like ground subsystems. Through such incremental growth, total system capacity can be increased by another 300k to 700k VG circuits with no more than a 4% reduction in the original space-based capacity.

▪ **Low System Cost Yields Low Prices** -- The cost to construct, launch and insure two geostationary satellites of CELSAT's design is less than $500 million which, given its tremendous space capacity, translates into a potential capital recovery cost of less than $0.01/min. of traffic over the expected ten year satellite life. This inherently low cost per minute, in turn, will permit rates to the end user well in the range of $0.25/min. or lower (end-to-end) for VG access, thereby bringing the cost well within the range of the largest potential segment of the end user market.

▪ **High Capacity Yields Maximum Functionality** -- Aside from certain technical limitations, the one factor which makes high speed and/or heavy use of today's mobile voice systems for fax and bidirectional circuit-switched data (let alone compressed video) economically impractical is that premium priced voice demand consumes virtually all of the available channels. In contrast, CELSAT's enormous capacity makes it economically feasible to offer synchronous and asynchronous bandwidth-on-demand up to reasonable limits (e.g., 144 kbps (i.e., ISDN)), and very high speeds are possible under special subscription terms, without penalizing the grade of service available for ordinary voice, fax and other lower speed users. Thus, by deploying one well designed and very flexible and versatile HPCN system, policy makers can satisfy the public's thirst for a wide range of near and intermediate term services while still leaving spectrum for others.

▪ **High Capacity and Hybrid Structure Offer Opportunities for Multiple Entry** -- This country is committed to pro-competitive policies which not only ensure a variety of services at competitively established prices, but maximum opportunity for multiple providers. CELSAT's HPCN assures both the greatest variety of services and at competitive prices. Specifically, CELSAT has proposed licensing structures whereby both its space and ground segments can be licensed separately and operated independently by others. In addition, and alternatively, it has demonstrated (without technical challenge) that its geostationary satellites with CDMA spread spectrum modulation can share the RDSS L/S-band (or other spectrum) with either IRIDIUM or the other Big LEOs, thereby satisfying the public's perceived demand for both near term domestic services and longer term global services. Either way, CELSAT's HPCN enhances the end users' access to more low cost services with the least impact on scarce spectrum needed for yet other, future services.

▪ **High Capacity and Coordinated Network Control Facilitate An Open Interface-Like Ability To Work With Emerging New Systems** -- In contrast to both past designs (e.g., Tritium) and new proposals by IRIDIUM and certain other Big LEOs, CELSAT's HPCN capacity, proprietary network controller and proposed use of an emerging CDMA coding standard enable its space segment transparently and without conscious end user intervention to accept the signals of any CDMA-compatible handsets operating nearby in the 2 GHz band, subject to cooperating arrangements entered into with the competing system operator. This will mean, for example, that domestic CDMA-based 2 GHz PCS users could have effective nationwide roaming capability outside their ordinary service areas, and even users of other similar CDMA 2 GHz global or internationally-based systems using compatible terminals could be serviced by CELSTAR while traveling in the U.S. Thus, CELSAT not only promises maximum service availability to its own customer base, but it will enhance the utility and, thus, the economic viability of yet other competing wireless systems.

▪ **High Volumes Assure High Production of U.S. Components and Network Resources** -- Yet another factor in assuring maximum end user access to a true variety of low cost new services is the level of competition in the provision of both the end user equipment and the network infrastructure components. In contrast to any other existing or proposed new mobile system or service (each of which either lack significant capacity or require proprietary devices or interfaces), CELSAT's shear capacity to service between 20-30 million users concentrated throughout the U.S. will create domestic demand for the production quantities necessary to stimulate multiple suppliers of handset hardware of both proprietary and generic designs. CELSAT's space and vast terrestrial cellular and PCS-like networks, as well as its intense dependency on interconnecting landline facilities, will create new demand for signaling systems, switches, controllers and other infrastructure components, and will otherwise most effectively utilize our existing high capacity fiber infrastructure. Together, these secondary commercial opportunities will not only assure ongoing innovation leading to still more new and improved services over the HPCN platform, but they will also contribute significantly to the overall well being of the economy.

▪ **CELSAT's Simplicity Could Mean Earliest Possible Deployment and Service Availability** -- CELSAT's proposal not only promises to bring low cost, high volume 21st Century wireless capability to the U.S. using all-american technologies and resources, but it can do so in the earliest possible time frame. As noted above, after almost one year of exposure to public debate and criticism before the FCC no party has rebutted CELSAT's claims as to its technical simplicity and feasibility. No new technology needs to be developed; everything necessary already exists or is otherwise doable right here in the United States. Moreover, to be economically viable and technically operational, CELSAT does not require any international approvals, partnerships, or spectrum coordination; nor will it present interference conflicts along the borders of Canada or Mexico, or with other primary users of the former RDSS band. All that is needed is FCC approval, and with that CELSAT could have minimum service under way in two years, and satellite service in place in three years.

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ATTACHMENT B

LEO-GEO COMPATIBILITY

In its August 5th Notice (Docket 92-28 on page 7), the FCC has explained part of its decision not to include CELSAT in the RDSS bands on the basis of the fundamental incompatibility of LEO and GEO systems. We would argue that the issue of LEO-GEO compatibility requires a fresh reexamination on the basis of the CELSTAR development.

First we note that the issue, if any, of band sharing compatibility between LEOs and GEOs is *not* on the downlink for the following reas on: Given that all the current generation of mobile satellites are designed for essentially omnidirectional subscriber unit receiving antennas, and since all have roughly the same required Eb/No and data rate, it follows that GEOs or LEOs all require about the same ground level *flux density* per user on the user down link for satisfactory performance. So that on the down links, LEOs and GEOs are inherently on a levelled basis with respect to band sharing capability.

The uplink is a different matter. The first proposed Mobile satellite (now AMSC), utilizing **GEO**synchronous orbit required relatively high user unit antenna gain (to 12 dB) and EIRP (to 21 dBW) to support high grade voice. Later, **LEO** proposals showed it possible to support high grade voice with omnidirectional antennas and much lower subscriber unit EIRP of the order of 0 to 3 dBW.

Clearly there was an uplink band sharing incompatibility between two such systems. The proposed LEO systems were able to operate with much more desirable omnidirectional user antennas, and at subscriber unit EIRP some 20 dB smaller than the proposed GEO. Band sharing of such systems with GEO (as represented by AMSC), however, appeared almost impossible. The LEO uplinks in particular would be quite vulnerable to the 20dB or so larger subscriber unit EIRP from the AMSC system. It was natural to associate this power discrepancy and band sharing incompatibility with the range disadvantage (some 15-30 dB) of GEO as compared to LEO systems and to regard that advantage as generically inherent to the LEO and GEO concepts.

What the CELSTAR development has now shown, however, is that such subscriber unit EIRP discrepancy is *not* inherent to all GEO systems, but rather, particular to the older AMSC design. The CELSTAR design *more than overcomes the range disadvantage of synchronous orbit by very high satellite antenna gain, practical only at geosynchronous orbit.*

The reasons for this can be seen from the up-link budget equation for the received Eb/No:

$$\frac{E_b}{N_o} = \frac{EIRP_{user}\ G_{sat}\ \lambda^2}{(4\pi)^2\ R^2\ \ kT_s R}$$

which may be rewritten as an equation for the required user unit EIRP in terms of required Eb/No:

$$EIRP_{user} = \left(\frac{4\pi}{\lambda}\right)^2 \left(\frac{E_b}{N_o}\ kT_s R\right) \left(\frac{R^2}{G_{sat}}\right)$$

The first term on the right is a constant, and the second doesn't vary a great deal between reasonable current designs. There is relatively little a designer can do to reduce Eb/No or Ts or data rate, R, below those assumed by all the current competing MSAT proposals. So one would anticipate that in an efficient design, subscriber unit EIRP should be generally proportional to R^2/G_{sat}. This is shown to be roughly the case in the following comparison table:

TABLE 1

SYSTEM	R km	$G_{sat}(R)$ dB	$R^2/G(R)$ dB (rel)	DESIGN EIRP dBW
AMSC	36000	33.8	14.6	21 (Toll Quality)
MOTOROLA	1644	17.5	4.1	6.9 (Peak Pulse)
ELLIPSAT	1250	8	11.2	.3
LORAL/QUALCOMM	1390	3	17.2	.3
TRW	12800	25.4	14.0	-.5
CONSTELLATION	1018	-2	19.5	1.0
CELSAT	36000	48.4	0.0	-9.0

This shows that the differences in subscriber unit EIRP are, as one would expect, largely explained by the parameter $R^2/G(R)$. AMSC stands out from this comparison because of relatively less efficient coding and modulation and MOTOROLA because of the high peak power resulting from use of a low duty cycle Time Division Duplexing structure. The important thing here with respect to compatibility is that CELSTAR, the only current design GEO system in this comparison, stands out as having the *lowest* subscriber unit EIRP. We view this as not being *in spite* of the GEOsynchronous altitude,

but rather because of the even more important high satellite antenna gain made prctical by stationary orbit.

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BAND-SHARING COORDINATION OF WIDE-BAND MOBILE SATELLITE SERVICES.

Jack Mallinckrodt
CELSAT
August 31, 1992

INTRODUCTION

The FCC has before it a number of applications envisioning band-sharing in the mobile satellite service. Some of these imply an unqualified ability and willingness to share the allocated band with other system proposers. Other applicants have put forth arguments that their system provides a more efficient means either alone, or band-sharing on an FDMA frequency basis. We argue that neither such extreme position is technically correct.

Even with the advantages of spread spectrum, the capacity that can be derived from a given band is a limited resource. As more sharing users are added to a given band, the general interfering background flux density increases proportionally and the circuit capacity of each other participant is diminished accordingly. Without appropriate flux density control This can result in a *significant reduction in total US capacity.*

We can best illustrate this with one of the results to be developed later in this paper. CELSAT proposes a system design which, on the basis of sole occupancy of a 16.5 MHz band at a flux density of 2.9 FDU[1] would provide approximately 60,000 US circuits capacity. Considering all the major CDMA proposers that are compatible in principle, (GLOBALSTAR B, ELLIPSO, ARIES, ODYSSY, and CELSTAR) their total proposed US capacity is 71,000 circuits in separate bands. *Sharing* a single band between these users, each at their requested flux density, would reduce their *total* US capacity from 71,000 to 33,000 circuits at a much greater flux density of 9.6 FDU. This is significantly worse than CELSTAR alone (60,000 circuits) at 2.4 FDU.

Cumulative flux density is the controlling factor in this issue. Thus in considering CDMA multiple band-sharing proposals, it may become incumbent upon FCC to devise means of *allocating flux density* as well as frequency bands, and to follow a sound mixed strategy of frequency division in multiple bands as well as CDMA band-sharing.

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[1]. For convenience, the "FDU" is defined here as a unit of power flux density equal to -144 $dBW/m^2/4kHz$.